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NASA TECHNICAL TRANSLATION NASA TT F-15,347

DC GENERATOR FOR KOLKHOZ WIND POWERED GENERATORS

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(NASA-TT-F-15347) DC GENERATOR FOR KOLKHOZ WIND POWERED GENERATORS (Linquistic Systems, Inc., Cambridge, Mass.) 11 p HC $4.00 CSCL 10A

N74-17786

Unclas

G3/03 31327

Translation of: "Generator postoyannogo napryazheniya dlya kolkhoznykh vetroelektrostantsiy," Elektrichestvo, Vol. 61, pp.14-16, 1940.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
MAR 1974
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NASA STI FACILITY
INPUT BRANCH

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546 MARCH 1974

STANDARD TITLE PAGE

1. Report No. NASA TT F-15,347	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle DC GENERATOR FOR KOLKHOZ WIND POWERED GENERATORS		5. Report Date March 1974
		6. Performing Organization Code
7. Author(s) K. I. Shenfer and A. A. Ivanov		8. Performing Organization Report No.
		10. Work Unit No.
9. Performing Organization Name and Address LINGUISTIC SYSTEMS, INC. 116 AUSTIN STREET CAMBRIDGE, MASSACHUSETTS 02139		11. Contract or Grant No. NASW-2482
		13. Type of Report & Period Covered TRANSLATION
12. Sponsoring Agency Name and Address NATIONAL AERONAUTICS AND SPACE ADMINISTRATION WASHINGTON, D.C. 20546		14. Sponsoring Agency Code

15. Supplementary Notes

Translation of: "Generator postoyannogo napryazheniya dlya kolkhoznykh vetroelektrostantsiy", Elektrichestvo, Vol. 61, pp. 14-16, 1940.

16. Abstract

The use of carborundum-graphite resistors to control the voltage output from small wind-powered generators is described. These generators can be used for collective farms. Experiments were performed for devising methods of regulating, in particular, DC generators, to supply constant voltage, and a new type of nonlinear resistor was developed for use as a regulator.

17. Key Words (Selected by Author(s))	18. Distribution Statement UNCLASSIFIED - UNLIMITED

19. Security Classif. (of this report) UNCLASSIFIED	20. Security Classif. (of this page) UNCLASSIFIED	21. No. of Pages 11	22. Price $4.00

DC GENERATOR FOR KOLKHOZ WIND-POWERED GENERATORS

K. I. Shenfer and A. A. Ivanov

The possibility of extensive use of windmills of simple design and comparatively cheap construction, which automatically adjust the output of the blade depending on the wind, within ±25% of the average rotational speed, requires electrical regulators or regulating systems for direct current for normal supply of consumers of electrical energy. /14*

In conjunction with applications to small and medium sized wind-powered generators, the author performed a study of a number of methods of regulating DC generators to allow a constant voltage output at the Energy Institute of the USSR Academy of Sciences. A new type of nonlinear resistor was developed as a regulator. These problems will be discussed in this paper.

Nonlinear resistors. In recent years, the technical literature has seen increasing mention of work devoted to problems of nonlinear resistors. Thryite, the vaccum tube, the "auto-valve" made by the Westinghouse Company and other similar materials and instruments which have the indicating nature of a volt-ampere characteristic, are used in devices to protect against over voltages and in other fields of technology.

In order to use the characteristics of a volt-ampere characteristic of certain ceramic materials for the regulation of machines with respect to constant voltage, we performed a study of many

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*Numbers in right-hand margin indicate pagination in foreign text.

ceramics with different additives. For normal voltage to DC generators (120-220 volts), it was found to be most advantageous to use a mixture of live-crystal drilling carborundum with graphite.

Figure 1 shows the volt-ampere characteristics of eight carborundum-graphite samples, whose data are listed in the table below:

Number of Sample	13	14	15	21	25	16 and 24	17
Content of carborundum, in %	90	85	83	82	80	75	70
Content of graphite in %	10	15	17	18	20	25	30

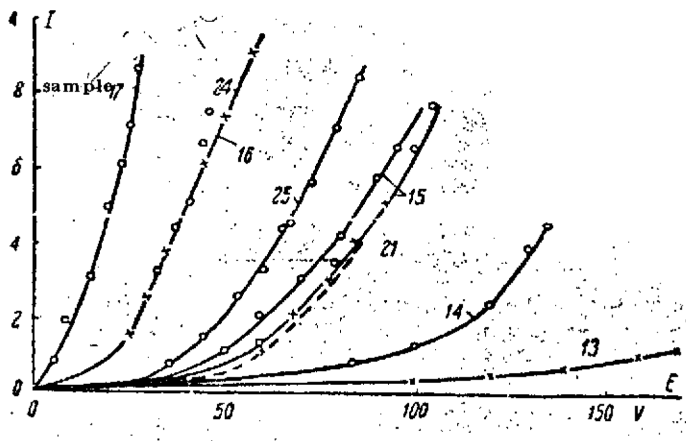

Fig. 1. Volt-ampere characteristics of carborundum-graphite samples.

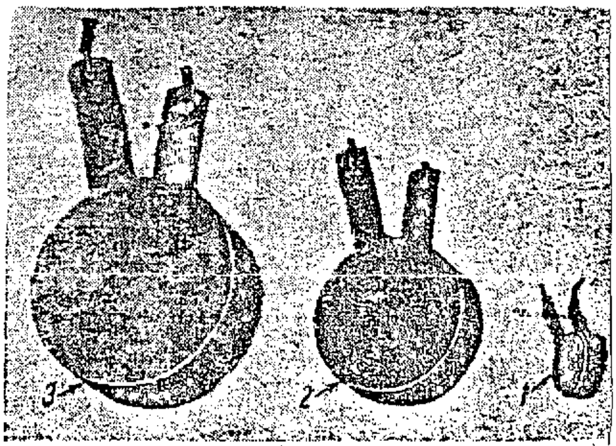

Fig. 2. Samples of carborundum-graphite resistors with brass electrodes. 1--5 volts; 2--20 volts; 3--130 volts.

As we can see from the t able and the curves in the figure, the decrease in the percentile content of graphite in the sample increases its resistance and decreases the curvature of the volt-ampere characteristics.

Particular attention should be paid to samples no. 14, 21, 15, 25, 16, and 24. Their volt ampere characteristics, at low voltage levels, are close to linear, while the angle of the slope of the characteristic with respect to the abscissa is very small. This corresponds to the low current values. If the voltage increases above a certain point, the current passing through the nonlinear resistance will begin to increase sharply and accordingly the curves of the characteristics will begin to bend upwards.

The law of the path of a curve of a volt-ampere characteristic for carborundum-graphite resistors can be expressed by the empirical formula which we represent as

$$i_N = e_N^3 + 3(e_N - 1)^2,$$

where i_N is the current of the nonlinear resistor, e_N is the applied voltage.

The technological process of production of a nonlinear resistor of the carborundum-graphite type is extremely simple. The powdered components of the resistor, in appropriate proportions (20% graphite and 80% carborundum) are carefully mixed, moistened to the consistency of a thick mass using glyptal cement and then compressed by means of a special pool in a simple metal cylinder. The cylinder is placed in an electric furnace which is heated to 100-150°C (increasing the temperature further may cause the graphite to be burned out of the mixture and consequently destroy the resistor). Following total drying in the electric furnace, the solid mass, in the form of a disc, is cut from the cylinder which results. A final layer of metal is sprayed onto its end surface which serves as a contact between a nonlinear resistor and the applied conductor.

Figure 2 is a photograph of three such resistors, designed for different voltages (5, 20 and 130 volts). Here the fine brass electrodes with wires replace the sprayed on metal. /15

For very low voltage machines (5-10 volts), requiring a thickness of layer of resistor that is so small that it is sufficient to apply a mixture of carborundum and graphite mixed with glyptal cement in the form of a paint to metal (for ensuring strength) electrodes and dried in this form. The dimensions of the disc of the nonlinear resistors are determined by the power and voltage of the generator, the operating mode and the cooling conditions. In Figure 2 the largest disc has a diameter of 50 mm and is 20 mm tall. It is intended for adjusting and keeping constant the voltage to the TN-17.5 2.5 KW, 115V, 18.7A machines.

The nonlinear resistors of the carborundum-graphite type are strong, shock-resistant and resistant to impacts, not subject to aging and capable of being heated to 140+150°C. In this case, if the operating conditions are unfavorable in regard to temperature, the resistance must be placed in a tank of oil and fitted with cooling discs.

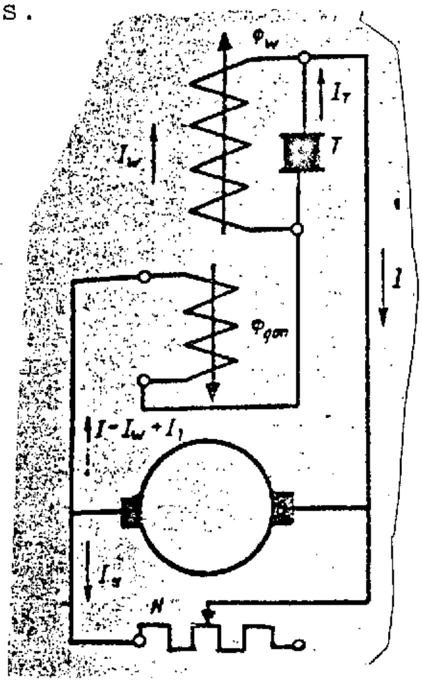

Fig. 3. Diagram of the regulation of a DC generator to ensure constant voltage.

Study of the system for regulation of a DC generator to ensure constant voltage. We conducted a study of several ways of connecting nonlinear resistors into the circuit of a DC generator. The maximum regulatory effect was produced by the system[1] shown in Figure 3 with a nonlinear resistor and a demagnetizing coil. The demagnetizing coil is connected in series with the main shunt winding, to whose terminals the nonlinear resistor is connected. The currents in both windings Φ_W and Φ_{add} are in opposite directions.

The operating principle of the circuit is as follows:

When the number of revolutions of the generator increases, the voltage on its brushes will increase. However, beginning at some critical voltage on the terminals of the shunt winding, the value of the nonlinear resistance begins to drop sharply. In this connection, the current I which is passing through the demagnetizing coil increases and its current Φ_{add} increases as well. As far as the current Φ_W is concerned, in the main shunt winding, it will decrease, since the value of the nonlinear resistance T has decreased and partly shunted the shunt winding.

Thus, in this system the regulation is accomplished in two ways: (1) An increase in the effect of the demagnetizing coil and (2) shunting (i.e., weakening) of the main shunt winding.

The results of the joint action of the nonlinear resistance and the demagnetizing winding is a very insignificant rise in the voltage at the terminals of the generator with a considerable change in the number of its windings.

Figure 4 shows the working curves obtained from an experiment

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[1] Inventor's claim No. 30074 of K. I. Shenfer.

in the regulation (to obtain a constant voltage) of the PN-85, 230 volt, 31.3 ampere machine. With a change in the number of revolutions of the generator from n_1 = 2170 rpm to n_2 = 2900 rpm, the voltage at its terminals increased by a total of 2 volts, corresponding to less than 2% of the rated voltage.

<u>Demagnetizing coil</u>. The demagnetizing coil carries the total exciting current I: it carries both the current of the main shunt winding I_w and the current of the nonlinear resistor I_1:

$$I = I_w + I_T.$$

Therefore the cross-section of the conductors of this winding should be selected so that it has a larger cross-section than the shunt winding by 20-30%. The demagnetizing coil is wound on the cores of the shunt winding. If the generator has a compound winding, it can be covered with the demagnetizing coil instead. The number of turns of the demagnetizing winding usually is sufficient if it is approximately 8-10% of the number of turns of the shunt winding. In this connection, the weight of the copper in the exciter increases 10-12%.

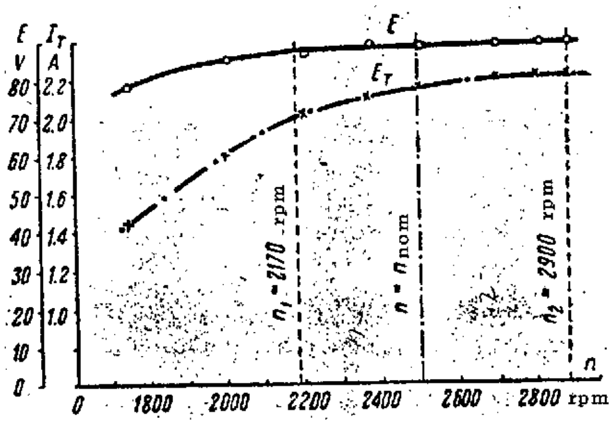

Figure 4. Voltage E on the terminals of the generator and the current I_T in a nonlinear resistor as a function of the number of revolutions during operation according to the system shown in Figure 3.

The coefficient of useful effect of the generator with nonlinear resistance with a nominal load naturally is somewhat less than the normal machine (approximately by 10%). But we must keep in mind that the unregulated generator requires several additional devices[2] to maintain the voltage within the set limits. Hence, its efficiency must take into account the losses in these /16
additional devices.

The simplicity of the generator circuit with nonlinear resistor and its reliability of operation allow the authors to consider the possibility of using it not only for Kolkhoz wind-powered generators but also in other areas of technology. These could be machine used in the electrical equipment of factors, synchronous generators operating at low and medium power levels, and so forth.

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[2]Such devices include buffer storage batteries, vibrator-type regulators, and so forth.

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